Simulation of emotional processes in decision making

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Abstract

Human emotional capabilities have recently been considered essential in decision making. An emotional model applied to the *Gambling Task* game is outlined here. The aim is to be able to simulate a human behavior with respect to the emotional feedback created by the environment. To do so, an OCC (Ortony, Clore and Collins) model emotion type is used to define several criteria representing a human emotional structure. Moreover, a probabilistic graph is brought into play for the behavior representation through the game environment. Results are promising and show that the emotional reactivity is coherent and globally lead the player to his objectives.

Keywords: emotion, decision making, gambling task, behavioral graph

1 Introduction

This study was brought to life from the assumption that emotion could be part of human intelligence and particularly be of a great help in decision making. Indeed, Damasio's works [4] have proved that with a lack of emotional activity, a human being is hardly able to make a reasonable decision when facing a problem.

The objective of this work is to simulate emotions using a sociological approach in a very particular context in the world of cognitive psychology: the *Gambling Task*. To do so, we worked together with the *Psychology and cognitive neurosciences laboratory* of Rouen (France). This collaboration will allow us to draw a parallel between human behaviors and computed simulation outcomes.

After having a look at the sociological aspects of emotions, we will develop a model in response to the problem of emotions simulation. Finally, the results obtained and the planned perspectives will be presented.

2 State of the art

When looking at the different definitions of emotion on the internet or in any kind of book, we realise how difficult it is to comprehend all the aspects involved in emotional processes. Hence, several sociologists and psychologists have tried to make a list of all the possible human emotions. Most of them have finally determined a few basic emotions that are considered being sufficient to represent any human feeling. For instance, Ekman, a well-known American psychologist, describes 6 basic emotions: anger, disgust, fear, joy, sadness, surprise.

Apart from the actual distinction of these emotional concepts, psychologists, from their point of view, tried to make different types of categorisations for emotions. One of the most famous is the *OCC model*, made by three psycho-cogniticians: Ortony, Clore and Collins [15].

		+	-
Consequences of events	For others	Happy for	Resentment
		Gloating	Pity
	For self	Hope	Fear
		Joy	Distress
Action of Agents	Self Agent	Pride	Shame
		Gratification	Remorse
		Gratitude	Anger
	Other Agent	Admiration	Reproach
		Gratification	Remorse
		Gratitude	Anger
Aspects of Objects		Love	Hate

Figure 1: The OCC Model

According to these three authors, emotions come from the appraisal of three different aspects of the world: the consequences of events, the actions of agents and the perception of an object. For instance, an event which aims at realising a particular objective will create joy; an action from an agent (individual) that would go against his principles will end up with a feeling of shame; the perception of an object can be disgusting depending on the agent preferences.

Therefore, the OCC model (see figure 1) defines three classes of emotions, according to the emotional context they refer to, in which we have smaller groups concerning the person responsible for the triggering of the action (generally 'other' and 'oneself'). Each emotional dimension is represented by an antagonistic couple, like *joy* and *distress*, or *love* and *hate*, in which an individual's emotional state is located, somewhere between the two bounds.

3 Model of emotion

Within the framework of this project, the modelisation which is used is based on the OCC system described above. For each antagonistic couple previously listed, we associate a fuzzy logic sigmoid function called μ, defined on the interval $[-1;1]$, as follows:

$$\begin{array}{rccc} \mu : & [-1;1] & \mapsto & [0;1] \\ & k & \rightarrow & \mu(k) \end{array}$$

The variable named k represents the current position of the emotional criterion on the curve. According to its value, the actual emotional criterion is, more or less, positive or negative. Therefore, if k equals 0, the emotional state related to the couple *joy-distress* is neutral. The more k is close to -1, the more important the feeling of distress, and vice versa, the more k is close to 1, the more important the feeling of joy.

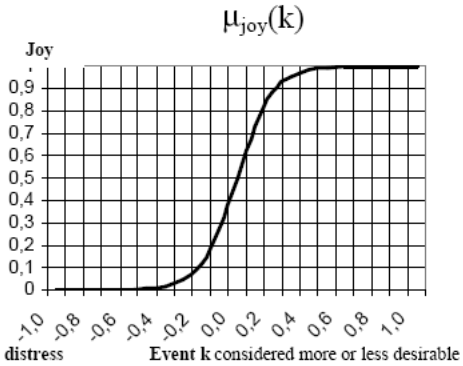

Figure 2: The μ_{joy} function

The shape of this sigmoid function can vary, with respect to the feeling couple which is modelised [7]. However, it can also change depending on the actual individual involved. As a result, an easily depressed person will have a very steep *joy-distress* curve, with the ability to go quickly from a great joy to a deep sorrow. On the other hand, a mentally strong person will end up with a gentle curve.

Here is the sigmoid function used in the model:

$$\mu(k) = \frac{1}{(1 + e^{-\lambda k})}$$

The λ value is proportional to the curve slope.

Gambling Task

The Gambling Task (see Bechara and Damasio's works [4]) is a well-known test which aims at stimulating the emotional processes of a player by giving him some money and proposing him to increase his capital through a card game.

This game consists of four decks of cards. On each card a number representing a certain amount of money, positive or negative, is written. For each card taken, the player wins or looses money with respect to the amount indicated on the card. The game stops when a hundred cards have been taken.

Of course, in order to make the game more interesting, the player is told that amongst the four packets, two of them are more profitable than the other two. Indeed, the average sum of all the cards located in a profitable packet is positive, meaning that the player has more chance to earn money. However, the sums written on these cards are not high. Eventually, the profitable packets make the player earn small amounts of money without loosing much. On the other hand, the bad packets are not profitable at all, and make the player loose a lot, even more than he will ever earn on these packets.

Finally, the player's goal is to collect money by identifying the good packets. He will then unconsciously develop a strategy to achieve this goal.

Probabilistic behavioral graph

During the game, the player obeys a behavioral graph that describes the environmental protocol. In other words, each packet is represented by a state in the graph, and a connection between two states is a choice that the player made to go from a packet to another.

In the following example (figure 3), the player has just taken a card from deck 1 and is planning to choose the next card. He has four possible choices: staying in packet 1 or changing for packet 2, 3 or 4.

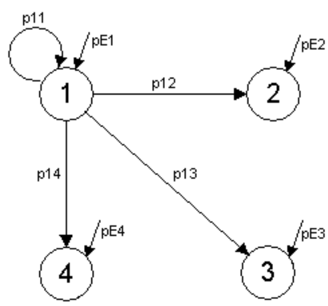

Figure 3: The behavioral graph

Each possible choice is linked with a particular probability p, calculated from the previous results obtained in the four decks. Hence, the sum of the four probabilities stemming from the first deck must be 1.

The p_{En} are the entry values for each state (used only to choose the first card of the game).

Decision making process

Decision making consists in :

1. Defining the values in the behavioral graph according to the player emotional state and the history of every deck of cards. To do so, we need to calculate every P value in the graph, knowing the emotional $\mu_i(k_i)$ curves (i being an emotional couple), and using valence function α_i as follows :

$$\forall transition\ t\ \forall criterion\ i \left\{ \begin{array}{ll} p_i = & \alpha_i(t)\mu_i(k_i) \\ P_t = & \sum p_i \end{array} \right.$$

2. Calculating the score of every deck, using the gains and losses that occurred so far (the history of each deck). The default equation used is :

$$Score = \frac{(gains \times gainMax) - (losses \times lossMax)}{(gains \times gainMax) + (losses \times lossMax)}$$

The $gains$ and $losses$ values correspond to the sum of all the positive and negative cards that have been taken on the deck, $gainMax$ and $lossMax$ being the best and the worst card taken. When calculated, the $score_i$ value is then multiplied by the probability value P_i, in order to influence the latter positively or negatively.

3. Normalising the P_i values, so that their sum equals 1.

4. Choosing randomly a packet in which the player is going to take a card, according to the P_i values.

Emotional feedback

Emotional feedback is the effect of decision over the mind. In the Gambling Task, this phenomenon depends on the game situation, described by the last card taken. The influence of the card over the player's emotion is composed of different parameters.

Firstly, we assume that the intensity of the emotion is directly proportional to the value of the card taken, positively or negatively.

Secondly, we need to take into account the capital of the player at the time he takes the card. Indeed, we can easily consider that a card indicating a strong loss will not especially have a big influence if the player has a lot of money at that time.

Finally, we consider that the emotional state of a normal human being can not be strongly modified, in a realistic manner. Therefore, the emotional feedback will not be computed directly through an equation but using a differential modification of the concerned parameters, with the idea that the emotional state is to be changed gradually, without brutal transformation.

Considering all these assumptions, we obtain the following equation:

$$k_i = k_i + \frac{v}{c} \times r \times \alpha_i$$

i : index of the emotional criterion;
k_i : value of the emotional criterion curve on the X axis;
v : value of the card taken;
c : player capital just before the draw;
r : "mind resistance" coefficient ($0 \leq r \leq 1$);
α_i : magnitude of the emotional criterion compared with the other criteria.

The r coefficient represents the player emotionalism, defined in the interval $[0; 1]$. It is his ability to keep his calm in high-rate emotional situations. The more this value is closed to 1 and the more sensitive the player is, and vice versa.

4 Implementation and results

ModEm is an application that directly implements the emotional model previously seen. It draws a probabilistic graph representing the Gambling Task environment and shows all the results related to the emotional state of the player as well as his situation in terms of money and decision parameters.

Moreover, it uses a special file format which describes the entire game protocol:

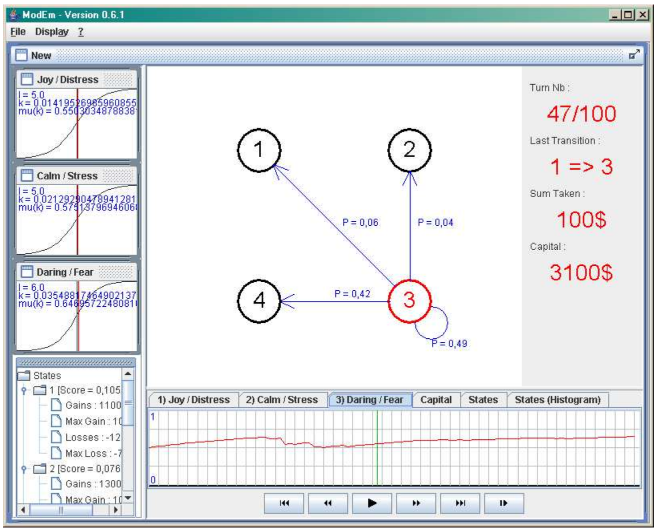

Figure 4: The graphical user interface

- The global parameters: number of turns and starting capital;

- The composition of the packets: number of packets, size and description of all the cards;

- The emotional system: emotional model used, emotional resistance, λ values for each curve, and starting k values.

```
*************************************
#ModEm - Version 0.6.1
*************************************

#TURN_COUNT 100
#CAPITAL 2000
#PACKET_SIZE 40
#PACKET_COUNT 4
#PACKET_CARDS 100 100 -500 ...
#PACKET_CARDS 100 100 -1250 ...
#PACKET_CARDS 50 50 -150 ...
#PACKET_CARDS 50 50 -250 ...
#FORCE_STATE 0 (1)
[#FORCED_STATES 0 2 4 3 1 ...]

#EMOTIONAL_MODEL KM
#RESISTANCE 0.5
#LAMBDA_VALUES 5.0 5.0 6.0
#K_VALUES 0.0 0.0 0.0

#ALPHA_VALUES 0.2 0.3 0.5
#PROBA_VALUES 1.0 1.0 1.0
#PROBA_CHOICE 1
#SCORE_CHOICE 1
```

Finally, the application is able to store its information, with the aim to allow the user to reach any previous played turn in the same game. It can also force the player to choose a particular packet for each turn by using a specified sequence of packet numbers written in the file.

Results

In this part, we will have a look at the obtained curves and graphs in order to analyse the global coherence of the application.

The behavioral graph initially describes four states corresponding to the four decks of cards, each state being valued 0.25, i.e. 25%. This is coherent since the player, before taking his first card, has no information about the decks. Therefore, their probabilities are equal.

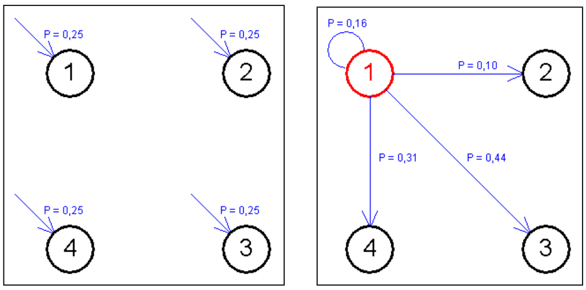

Figure 5: Example of game graph (start and end)

At the end of the simulation, probabilities change, allowing the game to distinguish the beneficial packets from the unfavorable ones. Hence, in figure 5, we clearly see that decks 1 and 2 (the disadvantageous packets) have respectively 16% and 10% of chance to be selected, wether decks 3 and 4 (the advantageous packets) have 44% and 31%.

The application also produces behavioral curves that give information about the evolution of the game and the emotional state of the player.

Emotional curves (see figure 6) are defined between 0 and 1 and show the different values of the $\mu(k)$ function according to time.

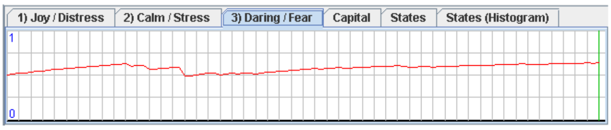

Figure 6: Emotional curve example ($\mu(k)$)

The capital curve (see figure 7) helps to see the evolution of the capital throughout the game.

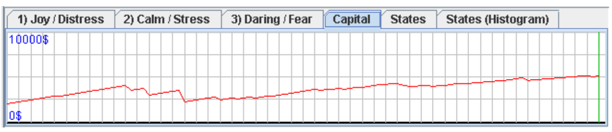

Figure 7: Capital curve example

Finally, the state curve (see figure 8) gives details about the different choices of packets. It can either be seen as a curve, or in the form of a histogram.

We can notice that the player has taken much more cards in packets 3 and 4 (the good ones), which means that he is naturally more attracted by these packets. This behavior is rather close to reality since a normal human being who plays the Gambling Task usually react that way.

5 Conclusion and prospects

In order to improve the player environmental comprehension, we aim to complete the model structure using cognitive agents. For a better adaptation to more important

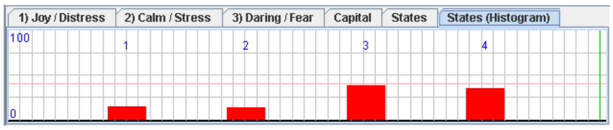

Figure 8: State histogram example

problems, we need to add a cognitive module that will be responsible for the player reasoning abilities and also memory issues.

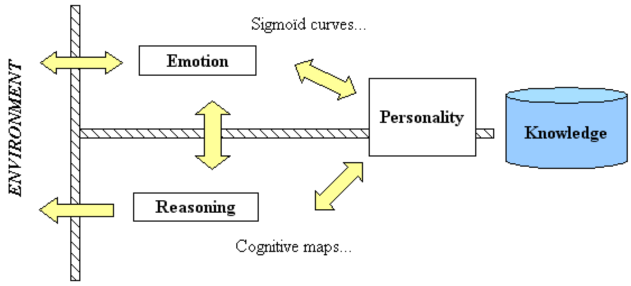

Figure 9: Mental representation of an emotional cognitive agent

In order to simulate cognitive capabilities, we use Fuzzy Cognitive Maps (FCM, see [3]). These maps are an adaptative manner of learning new knowledge from the environment by adding new states in the behavioral graph. Thus, this cognitive approach allows the player to develop his own personality through his experience stored in his knowledge base representing his memory. The emotion is then considered as a base layer for the decision making procedure, synchronised with the cognitive module. This evolutionary model can not only allow a growth of intelligence through experience, but also communication between agents, with the aim to share knowledge, feelings or points of view.

A second aspect which allows a better understanding is the validation of the application with the help of the experiments made in the *PSY.CO* laboratory in Rouen by comparing human nervous intensity measures with emotional behavior curves obtained within the program.

The OCC model, one of the most famous emotional representation created in the domain of sociology, has been successfully implemented in a computer simulation. The example of decision making through the Gambling Task context shows that emotion is a wonderful driving force which strongly leads the player with his choices. Results are consistent and globally correspond to a real human behavior when making a decision involving stress through the gain or loss of money.

However, emotion is a very complex entity, with many different parameters to take into account. So far, we used the OCC model to simulate emotion, but this model only consists of a list of basic emotions in a sociological point of view. There is no deep understanding of the origin and the evolution of emotional processes, and sociology usually has a meta-comprehension of human cognitive activity. In order to create an accurate simulation of human emotion, we need to take care of neurological issues and study the basics of cerebral organisation. This is probably the future of emotion simulation.

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